



**PATRIOT ENGINEERING
and ENVIRONMENTAL, Inc.**

Engineering Value for Project Success

**REMEDIATION WORK PLAN
FORMER TRI-COUNTY PETROLEUM SITE
508 S. JOHN STREET
CRAWFORDSVILLE, INDIANA
BFD #4171204; RLF CA# BF-00E48101-B
PATRIOT PROJECT NO. 19-0382-01E**

Submitted to: **INDIANA BROWNFIELDS PROGRAM**

Mr. Mitchell Smith
Office of Land Quality
100 N. Senate Ave., Room 1276
Indianapolis, IN 46204

Submitted for: **CITY OF ALEXANDRIA**

Mayor Todd Barton
City of Crawfordsville
300 East Pike Street
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April 19, 2019



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Submitted to:

INDIANA BROWNFIELDS PROGRAM

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TABLE OF CONTENTS

Section	Page
1.0 INTRODUCTION.....	1
1.1 PROJECT IDENTIFICATION.....	1
1.2 OVERVIEW OF CURRENT CONTAMINANT CONDITIONS.....	3
1.2.1 Discovery and Sources of Contamination.....	3
1.2.2 Remedial Measures Taken.....	3
1.2.3 Existing Deed Restrictions, Land Use Restrictions, or Environmental Notices.....	3
2.0 SITE BACKGROUND AND BASELINE PROJECT ASSESSMENT.....	3
2.1 SITE DESCRIPTION.....	3
2.1.1 Hazardous Materials.....	4
2.1.2 Previous Investigation Activities.....	4
2.3 GEOLOGIC INFORMATION.....	6
2.3.1 Regional Geology.....	6
2.3.2 Regional Hydrogeology.....	6
2.3.3 Site Geology and Hydrogeology.....	7
2.4 ECOLOGIC INFORMATION.....	7
2.5 POTENTIALLY SUSCEPTIBLE AREAS AND RECEPTORS.....	7
2.5.1 Potentially Susceptible Water Supply Sources.....	7
2.5.2 Potentially Susceptible Geological Areas.....	8
2.5.3 Potentially Susceptible Human Receptors.....	8
2.5.4 Potentially Susceptible Ecological Areas.....	9
2.6 CHEMICALS OF POTENTIAL CONCERN.....	9
2.7 POTENTIAL CONTAMINANT TRANSPORT MECHANISMS.....	10
2.8 POTENTIAL HUMAN EXPOSURE PATHWAYS.....	10
3.0 ADDITIONAL FIELD INVESTIGATION REQUIREMENTS.....	11
4.0 REMEDIATION PLAN.....	11
4.1 EVALUATION OF REMEDIATION ALTERNATIVES.....	12
4.1.1 Soil Excavation.....	12
4.1.2 Groundwater Pump and Treat.....	13
4.1.3 Air Sparging/Soil Vapor Extraction.....	13
4.1.4 In-Situ Chemical Oxidation (ISCO)/Enhanced Bioremediation.....	14
4.1.5 Monitored Natural Attenuation/Plume Stability Monitoring.....	14
4.1.6 Remedial Cost Evaluation of Viable Options.....	15
4.2 RECOMMENDED REMEDIATION STRATEGY.....	16
4.3 REMEDIATION STRATEGY IMPLEMENTATION.....	16
4.4 HEALTH AND SAFETY PLAN.....	18
5.0 MONITORING/CONFIRMATION SAMPLING PLAN.....	18
5.1 SOIL CONFIRMATION SAMPLING.....	18
5.2 GROUNDWATER MONITORING.....	18
6.0 COMPLETION OF REMEDIAL ACTIVITIES.....	20
7.0 SCHEDULE.....	21
8.0 REFERENCES.....	21

FIGURES

- 1 Site Vicinity Map
- 2 Site Map
- 3 Soil Boring Location Map
- 4 Soil Analytical Results Map
- 5 Groundwater Analytical Results Map
- 6 Geologic Cross-Section A-A'
- 7 Human Exposure Pathway Conceptual Site Model Flowchart

TABLES

- 1 Soil Analytical Results
- 2 Groundwater Analytical Results

ATTACHMENTS

- 1 Geologic Logs – 2018 Subsurface Investigation
- 2 Laboratory Report – 2018 Subsurface Investigation
- 3 IDNR Water Well Location Map, Water Well Log of Nearest Well, & Wellhead Protection Information
- 4 Nearby Wetland Map & Montgomery County Endangered Species List
- 5 COPC Information
- 6 Health and Safety Plan

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PATRIOT PROJECT NO. 19-0382-01E**

1.0 INTRODUCTION

Patriot Engineering and Environmental, Inc. (Patriot) was retained for the City of Crawfordsville (City) by the Indiana Brownfields Program (IBP) to prepare a Remediation Work Plan (RWP) for the Former Tri-County Petroleum site, located at 508 S. John Street, Crawfordsville, Montgomery County, Indiana (Site). The project is being funded through the United States Environmental Protection Agency (U.S. EPA) via a Revolving Loan Fund (RLF) Subgrant (RLF CA# BF-00E48101-B). The Site location is depicted on Figure 1. Regulatory closure of the Site is being pursued through the IBP using the Indiana Department of Environmental Management's (IDEM's) Remediation Closure Guide (RCG). The Site was entered into the IBP and assigned BFD #4171204.

1.1 PROJECT IDENTIFICATION

The Site is located at 508 S. John Street, Crawfordsville, Montgomery County, Indiana (Figure 1). The Site is an approximate 0.995-acre parcel, currently unoccupied. There are two buildings remaining at the Site, including a 2,482-square foot, one-story residential dwelling that was reportedly converted to office use, and an 1,800-square foot storage building. The Site is located in a residential area and is bordered by South John Street to the west, East College Street to the north, and railroad tracks and East Franklin Street beyond to the south. The ground surface at the Site slopes to the south toward Dry Branch Creek.

Historical fire insurance maps from 1907-1925 showed two residences on the northwest and west-central portions of the Site, and a coal yard and office on the southwest portion. The coal yard included a coal shed next to a railroad siding and an office and coal shed in the southwest corner of the Site. In the 1925 map, two oil houses are shown on the northwest portion of the oil/coal storage facility, and five above-ground storage tanks (ASTs) are shown on the central portion of the oil/coal storage facility. A rail spur extended across the central part of the Site and a coal storage area is shown in the south-central part of the Site. Subsequent fire insurance maps from 1949 and 1960 indicate that the rail spur was removed, a storage

building was constructed on the south portion of the Site, and 10 ASTs and a pump house were located in the central portion of the Site. The current Site layout is illustrated in Figure 2.

Phase I Environmental Site Assessments (Phase I ESAs) were performed in February and September 2018 and identified six documented historic spills at the Site between 1989 and 2012. The long history of the Site as a petroleum storage and distribution facility, as well as the documented spills, were considered Recognized Environmental Concerns (RECs). A geophysical survey completed in 2018 indicated a subsurface anomaly located along the southern edge of the south concrete pad. This anomaly was approximately 9 feet by 6 feet, and the GPR scan indicated it to be approximately 4 feet below ground surface, suggesting the anomaly may be an underground storage tank or vault.

According to the Crawfordsville, Indiana, quadrangle topographic map (United States Geological Survey [USGS] 2013), the Site is located in the northeast quarter of Section 5, Township 18 North, Range 4 West in Union Township, Montgomery County, Indiana. The topography of the Site slopes gently from the north to the south with a drop of approximately 7-9 feet from the northern to the southern edges of the Site. The average ground surface elevation is approximately 790 feet above mean sea level.

The Site is currently owned by the City of Crawfordsville. The Site and project contacts are:

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1.2 OVERVIEW OF CURRENT CONTAMINANT CONDITIONS

1.2.1 Discovery and Sources of Contamination

A subsurface investigation was completed by Patriot in November-December 2018 and included a geophysical survey, along with advancement and sampling of 12 soil borings. Boring locations are shown in Figure 3, and geologic logs for the borings are included in Attachment 1. The results of the geophysical survey indicated a subsurface anomaly located along the southern edge of the south concrete pad. This anomaly was approximately 9 feet by 6 feet and the GPR scan indicated it to be approximately 4 feet below ground surface, suggesting the anomaly may be an underground storage tank or vault.

The subsurface investigation results indicated soil and groundwater impacts in the former AST and loading rack areas and downgradient from these areas.

1.2.2 Remedial Measures Taken

No soil or groundwater remedial measures have been undertaken to date at the Site.

1.2.3 Existing Deed Restrictions, Land Use Restrictions, or Environmental Notices

There are currently no known deed or land use restrictions or environmental notices associated with the Site.

2.0 SITE BACKGROUND AND BASELINE PROJECT ASSESSMENT

The following sections present information on the Site history, summarize previous environmental investigations, and provide information on the physical location and setting, constituents of concern (COCs), and potentially complete contaminant exposure pathways.

2.1 SITE DESCRIPTION

The Site is an approximate 0.995-acre parcel, currently unoccupied. There are two buildings remaining at the Site, including a 2,482-square foot, one-story residential dwelling that was reportedly converted to office use, and an 1,800-square foot storage building. The Site is currently vacant. The Site layout, including the former AST and loading rack areas, the building locations, and the location of the suspected UST is illustrated in Figure 2.

2.1.1 Hazardous Materials

There are no records of hazardous materials being historically used at the Site. The specific petroleum products historically used and/or stored at the Site during bulk terminal operations are unknown; however, potential products include gasoline, diesel fuel, kerosene, fuel/heating oil, motor oil, hydraulic oil, and/or waste motor oil.

2.1.2 Previous Investigation Activities

A subsurface investigation was performed at the Site by Patriot in November 2018 and details of the work were reported in the *Geophysical Survey and Subsurface Investigation Report* (Patriot, December 21, 2018). A summary of the subsurface investigation is provided in the following paragraphs.

A subsurface investigation was completed by Patriot in November-December 2018 and included a geophysical survey, along with advancement and sampling of 12 soil borings. Boring locations are shown in Figure 3, and geologic logs for the borings are included in Attachment 1. The results of the geophysical survey indicated a subsurface anomaly located along the southern edge of the south concrete pad. This anomaly was approximately 9 feet by 6 feet and the GPR scan indicated it to be approximately 4 feet below ground surface, suggesting the anomaly may be an underground storage tank or vault.

The soil results are summarized in Table 1 and graphically depicted in Figure 4, and the groundwater results are summarized in Table 2 and graphically depicted in Figure 5. A copy of the laboratory report is included in Attachment 2. The soil results indicated that various petroleum related volatile organic compound (VOC) and polynuclear aromatic hydrocarbon (PAH) constituents were present in above their respective Indiana Department of Environmental Management (IDEM) Remediation Closure Guide (RCG) Excavation Direct Contact Screening Levels (EDCSL), RCG Industrial Direct Contact Screening Levels (IDCSLs), and/or RCG Residential Direct Contact Screening Levels (RDCSLs) in boring SB-4, located in the former loading rack area just west of the diked area where the ASTs were located. In addition, one or more soil samples from 7 other borings exhibited at least one VOC or PAH constituent above the IDEM RCG Migration to Groundwater Screening Level (MTGSLs).

The groundwater results indicated that one or more petroleum related VOC and PAH constituents were present at concentrations exceeding their respective Tap Water Screening Levels (TWSLs) in the samples collected from 5 borings (SB-1, SB-4, SB-5, SB-6, and SB-7). In addition, benzene was present above the IDEM RCG industrial Vapor Intrusion from Groundwater Screening Level (VIGWSL) in 4 groundwater samples (SB-1 GW, SB-4 GW, SB-6 GW, and SB-7 GW) and naphthalene exceeded the industrial VIGWSL in 3 groundwater samples (SB-4 GW, SB-6 GW, and SB-7 GW). Lead was detected in all groundwater samples collected at concentrations above the IDEM RCG TWSL; however, total lead analyses, which are run on unfiltered groundwater samples, often produce results that are biased high due to the presence of naturally-occurring lead in suspended sediment introduced during the sample collection process. Lead concentrations detected in the groundwater samples may not be indicative of actual lead concentrations in the groundwater, and are likely related to naturally occurring lead in the soils, as evidenced by the absence of lead impacts in soil above applicable screening levels.

2.2 Geographic Information

The political location information for the Site is:

County: Montgomery
Township: 18N
Range: 4W
Section: Northeast $\frac{1}{4}$ of Section 5
Latitude: 40° 2' 10.69"
Longitude: -86° 53' 32.90"

The ground surface elevation at the Site is approximately 790 feet above mean sea level (MSL) and the surface topography of the Site slopes gently to the south as shown on Figure 1. Storm water runoff at the Site is directed off-Site through sheet water flow to drains located on S. John Street to the west, and to a shallow drainage ditch located on the north side of the railroad tracks on the southern edge of the Site. The nearest drainage feature is Dry Branch Creek which flows toward the west approximately 900 feet south of the Site. The nearest regional drainage feature is Sugar Creek, located approximately $\frac{3}{4}$ -mile north of the Site. Based on topography, local groundwater flow in the general vicinity of the Site is likely to the south-southeast.

2.3 GEOLOGIC INFORMATION

2.3.1 Regional Geology

The Site is located in the Tipton Till Plain physiographic province of Indiana, and within the Middle Wabash Basin. The Tipton Till Plain is a nearly flat glacial plain covering central Indiana, underlain by thick glacial till and slightly eroded by postglacial streams. The unconsolidated materials are approximately 50 feet thick in the Crawfordsville area and overlie Mississippian-age siltstone and shale with minor sandstone and discontinuous limestone of the Borden Group.

2.3.2 Regional Hydrogeology

There are two aquifers in the Crawfordsville area including a discontinuous sand-and-gravel aquifer, and a upper weathered bedrock aquifer. The discontinuous sand-and-gravel aquifer, where present, range in thickness from 5 to 55 feet and are an important domestic water supply source. Well yields typically range from approximately 5 to as much as 300 gallons per minute (gpm). Most wells in this formation are artesian, with water levels rising higher than the top of the permeable unit, and the unit is confined above and below by low-permeability glacial till. The upper weathered bedrock aquifer in the Crawfordsville area is extensive and is present entirely as a result of weathering at and below the bedrock surface. Thicknesses range from 25 to 175 feet but significant permeability is generally limited to the upper 50 feet. Well yields in the upper weathered bedrock aquifer range from 2 to as much as 150 gpm.

Surface water runoff at the Site is primarily sheet flow. The edges and perimeter of the Site drain toward the western and southern property boundaries, into storm drains that are part of the City of Crawfordsville storm water sewer system (John Street) or into a shallow drainage ditch along the northern edge of the railroad tracks that border the southern edge of the Site.

A water well search was performed using the on-line database provided by the Indiana Department of Natural Resources (IDNR). A total of 379 wells were identified within an approximately two-mile radius of the Site, with the closest well located approximately 675 feet southeast of the Site, according to the IDNR Water Wells Enhanced Viewer. This well is identified as a 150-foot industrial water supply well, screened in sand and gravel above shale bedrock and owned by Sommer Metal Craft. A Water Well Record for this well is included in Attachment 3, along with a figure showing the locations of nearby wells, which was obtained

using the IDNR Water Wells Enhanced Viewer. According to the on-line IDEM Wellhead Proximity Determinator (Attachment 3), the Site is not located within a wellhead protection area.

2.3.3 Site Geology and Hydrogeology

Copies of the geologic logs for the borings advanced at the Site are included in Attachment 1. These logs were used to develop a geologic cross-section which is included as Figure 6. Based on these logs, the Site geology consists of silt/clay from the ground surface to approximately 10 to 15 feet below grade, underlain by silty sand/sand to at least 25 feet below grade. Groundwater was present in the sand unit at depths ranging from approximately 10-20 feet below grade. The groundwater flow direction was not determined, but is believed to be south-southwest based on topography.

2.4 ECOLOGIC INFORMATION

The nearest potential ecological feature is Dry Branch Creek, which flows toward the west approximately 900 feet south of the Site. The nearest regional drainage feature is Sugar Creek, located approximately ¾-mile north of the Site.

The U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) Interactive Mapper (USFWS, 2009) shows Dry Branch Creek as a riverine wetland; however, no other wetland areas are mapped along Dry Branch Creek in the vicinity of the Site (Attachment 3).

The IDNR lists five mollusks, seven insects, three reptiles, 16 birds, three mammals, and 16 plants on their Montgomery County threatened, endangered or rare species list (Attachment 5). Based on the location of the Site in an urban area that has been developed for more than 100 years, it is highly unlikely that any of these species would be present on or near the Site.

2.5 POTENTIALLY SUSCEPTIBLE AREAS AND RECEPTORS

2.5.1 Potentially Susceptible Water Supply Sources

Water from the municipal supply (City of Crawfordsville, which obtains its water from a municipal well field) is available in the Site area. Per the IDEM Wellhead Proximity Determinator on-line database (Attachment 3), the Site is not located in a wellhead protection area.

The IDNR water well mapper was used to identify water supply wells at or near the Site (Attachment 3). There are no water supply wells at the Site or at any of the nearby properties, all of which is provided with potable water by the City of Crawfordsville. A total of 379 wells were identified within an approximately two-mile radius of the Site, with the closest well located approximately 675 feet southeast of the Site, according to the IDNR Water Wells Enhanced Viewer. This well is identified as a 150-foot industrial water supply well, screened in sand and gravel above shale bedrock and owned by Sommer Metal Craft. A Water Well Record for this well is included in Attachment 3, along with a figure showing the locations of nearby wells, which was obtained using the IDNR Water Wells Enhanced Viewer.

2.5.2 Potentially Susceptible Geological Areas

According to the Indiana Geological Survey (IGS), the Site is not located in or near a Karst area (IGS, 2009). No other potentially susceptible geologic features, such as mined areas or fractured rock areas, are located near the Site.

2.5.3 Potentially Susceptible Human Receptors

The existing buildings at the Site are not occupied; therefore, there is no current vapor intrusion pathway. Vapor intrusion to future buildings at the Site is theoretically possible, based on the results of the investigation which identified benzene and naphthalene concentrations in groundwater in multiple locations in the former AST dike and loading rack areas, as well as one location in the far southwest corner of the Site) at concentrations exceeding both the residential and commercial/industrial vapor intrusion from groundwater to indoor air screening levels (VIGWSLs). However, as indicated in Section 5.4.3 of the IDEM Remediation Closure Guide (RCG), petroleum vapor intrusion generally does not occur when at least five feet of clean, unsaturated soil is present between the petroleum impacts and the building in question, and at the Site, the depth to water is greater than five feet. Consequently, while the potential for vapor intrusion to future on-Site buildings cannot be completely ruled out, vapor intrusion is unlikely based on the depth to water.

Residential areas surround the Site in all directions. Vapor intrusion in these areas related to the Site is unlikely due to the depth to water, but cannot currently be ruled out as long as groundwater impacts are above residential vapor intrusion from groundwater screening levels (VIGWSLs). Vapor migration via preferential pathways (e.g., utility line backfill material) is also possible and could result in a vapor intrusion threat. The nearest school is Crawfordsville Middle School, located approximately 1,300 feet southwest of the Site. This area is unlikely to

have the potential for vapor intrusion impacts from the Site, based on the distance and location respective to the Site; however, as stated previously, there is the possibility that vapor migration via preferential pathways could occur and thus present a potential vapor intrusion threat to the surrounding area.

2.5.4 Potentially Susceptible Ecological Areas

There are no natural areas located on-Site. Off-site ecological areas are not anticipated to be impacted due to the distance to the areas as described previously.

2.6 CHEMICALS OF POTENTIAL CONCERN

COCs detected above IDEM RCG screening levels present potential threats to human health and are considered as chemicals of potential concern (COPCs) that need to be addressed in remediation plans for the Site. Based on investigation results, COPCs in the indicated media are summarized below:

Shallow and Subsurface Soil	On-Site Groundwater	Off-Site Soil	Off-Site Groundwater
Benzene, Ethylbenzene, Xylenes, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Isopropylbenzene, n-Propylbenzene, Naphthalene, 1-Methylnaphthalene, 2-Methylnaphthalene	Benzene, Ethylbenzene, Xylenes, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Isopropylbenzene, n-Propylbenzene, n-Butylbenzene, n-Hexane, Naphthalene, 1-Methylnaphthalene, 2-Methylnaphthalene, Benzo(a)anthracene, Lead	None	Benzene, Ethylbenzene, Xylenes, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Isopropylbenzene, n-Propylbenzene, n-Butylbenzene, n-Hexane, Naphthalene, 1-Methylnaphthalene, 2-Methylnaphthalene, Benzo(a)anthracene, Lead

Other common petroleum COPCs found in soil and groundwater may also be present in soil in the former UST system areas. Attachment 5 includes information on the chemical, physical, and toxicological properties of these COPCs. Soil and groundwater data are summarized in Tables 1 and 2, respectively and soil and groundwater impacts exceeding IDEM residential and/or commercial/industrial screening levels depicted on Figures 4 and 5, respectively.

2.7 POTENTIAL CONTAMINANT TRANSPORT MECHANISMS

Surface soils in unpaved areas are not known to be impacted; therefore, surface runoff of soil contaminants will not occur. Subsurface soil contaminants could be leached to groundwater by storm water infiltration. Groundwater contaminants could be transported to down-gradient locations through groundwater flow.

COPCs such as benzene, toluene, ethylbenzene, xylenes, and naphthalene are volatile compounds that could volatilize upward through the subsurface. The potential for volatilization to the indoor air of future Site buildings at unacceptable concentrations is unlikely based on Section 5.4.3 of the IDEM Remediation Closure Guide (RCG), which states that petroleum vapor intrusion generally does not occur when at least five feet of clean, unsaturated soil is present between the petroleum impacts and the building in question. However, although the depth to water at this Site is greater than five feet, volatile COPCs could also potentially move laterally along preferential pathways, such as subsurface utility lines, and be transported to surrounding properties.

2.8 POTENTIAL HUMAN EXPOSURE PATHWAYS

The potentially susceptible areas discussed in Section 2.5 were evaluated in conjunction with the contaminated media, their locations and depths, potential transport mechanisms, and proposed land use to determine potentially complete human exposure pathways at the Site and surrounding properties. Potential receptors and potentially complete exposure pathways are summarized in the following table:

Potential Receptor	Potential Complete Exposure Pathways
On-Site or Off-Site excavation workers	Direct contact with impacted soils; inhalation of vapors containing elevated levels of COPCs; accidental ingestion of impacted groundwater
On-Site residents or commercial workers	Inhalation of vapors containing elevated levels of COPCs

The potentially complete human exposure pathways are depicted graphically on the Conceptual Site Model (CSM) presented in Figure 7.

3.0 ADDITIONAL FIELD INVESTIGATION REQUIREMENTS

The investigations performed to date have not delineated the extent of the released compounds to RCG screening levels in soil and groundwater. The extent of soil impacts should be able to be delineated as part of the proposed remedial activities (soil excavation as detailed in the following section), while post-remediation groundwater monitoring from a monitoring well network to be installed following completion of remedial activities will complete delineation of groundwater impacts.

4.0 REMEDIATION PLAN

The objective of remedial efforts is to reduce the COPC concentrations in on-Site soils and groundwater, resulting in subsequent reductions in off-Site impacts via natural attenuation to the point where groundwater monitoring can demonstrate plume stability. This would result in a restricted Site closure using Environmental Restrictive Covenants (ERCs) to prohibit groundwater use and restrict the impacted property use(s) to commercial/industrial purposes. Because commercial Site users will not be exposed to subsurface soil, and groundwater will not be used at the Site or in the surrounding area because they are connected to a municipal water supply, there are no currently complete exposure pathways for the soil and groundwater. Therefore, remediation goals will focus on eliminating the potential for future vapor intrusion by reducing the VOC concentrations in the on-Site soils and the on-Site/off-Site groundwater to below the applicable IDEM RCG screening levels. The remediation goals for the Site are as follows:

- Soils – IDEM RCG Commercial/Industrial Direct Contact Screening Levels
- On-Site Groundwater – Commercial/Industrial VIGWSLs
- Off-Site Groundwater – Residential VIGWSLs and Tap Water Screening Levels

These remediation goals are reasonable for the land use scenarios at the Site. The remediation goals for on-Site soil and groundwater and for off-Site groundwater are listed below.

COPC	On-Site Subsurface Soil (mg/kg)	On-Site/Off-Site Commercial/Industrial Vapor Intrusion Groundwater Screening Levels	On-Site/Off-Site Tap Water Screening Levels (ug/L)
Benzene	1,800	120	5
Ethylbenzene	480	NL	700
Toluene	820	NL	1,000
Xylenes	260	NL	10,000
n-Propylbenzene	260	NL	660
n-Hexane	140	NL	1,500
1,2,4-Trimethylbenzene	220	NL	15
1,3,5-Trimethylbenzene	180	NL	120
Naphthalene	3,100	460	1.7
1-Methylnaphthalene	390	NL	11
2-Methylnaphthalene	6,800	NL	36
Benzo(a)anthracene	29	NL	0.12
Lead	800	NL	15

4.1 EVALUATION OF REMEDIATION ALTERNATIVES

There is usually more than one technology available to achieve remediation objectives at any given site. These alternatives are considered and compared as part of the evaluation process leading to the selection of a remedial approach. Site geologic and hydrogeologic characteristics, cleanup objectives and the contaminants targeted for remediation play a primary role in selecting the appropriate remediation strategy. The estimated time to achieve regulatory closure and potential interruptions to ongoing site activities can also play a role in the selection of an applicable remedy. Overall costs are also a factor. The following remediation technologies were evaluated with respect to these criteria.

- Soil Excavation
- Groundwater Pump and Treat
- Air Sparging/Soil Vapor Extraction (AS/SVE)
- Chemical Oxidation/Enhanced Bioremediation

4.1.1 Soil Excavation

Soil impacts exceeding IDEM RCG Migration to Groundwater Screening Levels were identified in several locations in the former AST dike and loading rack areas. In addition, an apparent former UST is still present at the Site. Removal of the UST to prevent possible future

release(s) from fluids still present in the system is an essential component of the remedial approach for this Site. In addition, excavation of impacted soils identified during the 2018 subsurface investigation is also a potentially cost-effective and viable remedial option for this Site.

4.1.2 Groundwater Pump and Treat

Groundwater Pump and Treat (P&T) is an ex-situ remedial technology designed to reduce concentrations of contaminants dissolved in groundwater and adsorbed to saturated soil by removing contaminated groundwater from the subsurface by pumping, and then treating the water before it is discharged. P&T is not typically an effective means of removing dissolved-phase constituents from groundwater, compared to other mechanical removal technologies such as AS/SVE, and is primarily used only when plume control or capture is required. Most P&T systems quickly become diffusion-limited and are not cost-effective except when plume capture is necessary.

The relatively low permeability of the silty sand saturated zone renders conventional P&T unlikely at this Site. Vacuum-enhanced P&T (also known as dual-phase extraction, or DPE) is a technically-feasible remedial technology at this Site; however, the capital costs to design, install, and operate/maintain a P&T system are impractical with respect to the anticipated benefits, particularly given the apparent limited area of groundwater impacts. Consequently, since plume capture does not appear to be critical at this point, P&T and DPE were ruled out for this Site based on high cost and treatment time.

4.1.3 Air Sparging/Soil Vapor Extraction

Air sparging (AS) is an in-situ remedial technology that reduces concentrations of volatile organic constituents that are adsorbed to soil and dissolved in groundwater. This technology involves the injection of contaminant-free air into saturated soil, enabling a phase transfer of contaminants from a dissolved state to a vapor phase that travels into the unsaturated zone. The air is then vented to the surface through soil vapor extraction (SVE) mechanisms and treated as necessary. The same SVE system not only removes the sparged vapors, it also remediates unsaturated soil by using a vacuum to create airflow through the subsurface soil. The continual flow of air results in volatilization of contaminants either from adsorbed phase or free phase and ultimate removal by the system.

The geology at this Site is not suitable for AS/SVE, due to the lack of an adequate vadose zone to capture sparged vapors. In addition, as with P&T, the capital costs to design, install, and operate/maintain a AS/SVE system would be high.

4.1.4 In-Situ Chemical Oxidation (ISCO)/Enhanced Bioremediation

In-situ chemical oxidation (ISCO) involves injection of chemicals into the subsurface to rapidly oxidize adsorbed- and dissolved-phase hydrocarbons. Various chemicals have been employed in ISCO approaches, including persulfates, percarbonates, permanganates, hydrogen peroxide, and Fenton's reagent. The relatively small impacted on-Site area makes it a viable candidate for chemical oxidation; however, the COPC concentrations do not appear to be high enough to warrant such an aggressive approach, given easier options that are available.

Enhanced bioremediation for petroleum hydrocarbons involves injection of slow-release oxygen compounds into the impacted area to enhance long-term aerobic biodegradation of VOCs and PAHs via native microorganisms. It is seldom necessary to add aerobic bacteria to such injections, as they are almost always present in high concentrations at most sites and simply need oxygen to increase their degradation rate. Based on the estimated size of the impacted area, enhanced aerobic biodegradation via addition of oxygen-releasing compounds to the base of the excavated areas (and/or via injection) appears to be a viable, cost-effective option for this Site in conjunction with soil excavation.

The use of either of these options without removing the UST and the identified impacted soils is not a viable approach, since the residual soil impacts would continue to act as a source to impact groundwater. ISCO/Enhanced Bioremediation options generally are not highly effective in remediating impacted soils. Consequently, ISCO/Enhanced Bioremediation without soil excavation is not a viable option for this Site.

4.1.5 Monitored Natural Attenuation/Plume Stability Monitoring

Monitored natural attenuation (MNA) and plume stability monitoring relies on natural attenuation mechanisms to degrade petroleum hydrocarbons in soil and groundwater without other remedial efforts. If it can be demonstrated via statistical analysis that the plume is stable or receding, and is not or will not impact downgradient receptors, site closure can be achieved with institutional controls, specifically environmental restrictive covenants (ERCs) on properties where impacts exceed residential screening levels. Monitoring must be performed for a

minimum of eight consecutive quarters in order to obtain sufficient data to perform a valid statistical analysis.

The use of either of these options without removing the UST and the impacted soils in the tank dike and loading rack areas is not a viable approach, since the residual soil impacts could continue to act as a source to impact groundwater. However, enhanced bioremediation in combination with UST closure/soil excavation may be an effective option to enhance aerobic biodegradation of residual soil/groundwater impacts.

4.1.6 Remedial Cost Evaluation of Viable Options

Focused soil excavation, in combination with UST removal, and enhanced bioremediation via oxygen releasing compound application/injection is a practical, potentially cost-effective remedial option. Groundwater P&T would require the design, construction, and operation/maintenance of mechanical systems to remediate impacted groundwater, with attendant capital costs. ISCO has no capital costs, but is overly aggressive for this Site. MNA/plume stability, while not a viable option by itself, appears to be a good complement to remedial activities. The estimated total project costs for each option, including groundwater monitoring and closure reporting/well abandonment, are summarized below:

Soil Excavation/Enhanced Bio*	Annual Cost	Total Cost
UST Closure/Soil Excavation	\$146,000	\$146,000
Monitoring Well Installation	\$10,000	\$10,000
Groundwater Monitoring/Reporting	\$8,250/yr.	\$16,500
Closure/Well Abandonment	\$3,500	\$3,500
	<i>Estimated Total Cost</i>	<i>\$176,000</i>

*Includes UST removal/closure

Groundwater P&T*	Annual Cost	Total Cost
Capital Cost (System Installation)	\$175,000	\$175,000
Operation & Maintenance (O&M)	\$40,000/yr.	\$80,000 - \$160,000
Monitoring Well Installation	\$10,000	\$10,000
Groundwater Monitoring/Reporting	\$8,250/yr.	\$33,000 - \$49,500
Closure/Well Abandonment**	\$3,500	\$3,500
	<i>Estimated Total Cost</i>	<i>\$301,500 - \$398,000</i>

*Assumes 2-4 years of system operation, plus two years of post-operation groundwater monitoring

** Includes decommissioning of remedial system/electrical power drop

As this analysis indicates, Soil Excavation/Enhanced Bio is clearly the best option for this Site.

4.2 RECOMMENDED REMEDIATION STRATEGY

As detailed in the preceding paragraphs, focused soil excavation/enhanced Bio appears to be the most efficient, cost-effective option to address the residual impacts at this Site. The apparent UST identified during the subsurface investigation will also be removed. The soil excavation/enhanced bioremediation approach will be combined with installation of a permanent monitoring well network and completion of plume stability monitoring, as well as the use of ERCs, as necessary, to prohibit groundwater use and prevent future exposure. Details of the proposed implementation of this approach are provided in the following sections.

4.3 REMEDIATION STRATEGY IMPLEMENTATION

Excavation and Removal of UST

Patriot will oversee the excavation, cleaning, and removal of one UST, which is assumed to be 2,000-gallon capacity (contents unknown). Removal activities will be performed by an Indiana-licensed UST removal contractor.

Removal of Liquid/Sludge from UST

During the excavation and removal process, up to 1,500 gallons of petroleum-contaminated liquid and/or sludge will be removed from the Site, if necessary. SCS will perform the removal utilizing a vacuum truck for disposal and/or recycling.

Confirmatory Soil Sampling

Upon the completion of UST excavation, cleaning and removal, the excavation area will be evaluated for stained soils, free product, petroleum-type odors, and VOCs using a photoionization detector (PID).

Confirmatory sampling will be performed in accordance with the IDEM RCG, the IDEM RPG, and the UST Closure Assessment Guidelines, as well as the project-specific Quality Assurance Project Plan (QAPP). In addition, it is assumed that two soil samples will be collected from below the hydraulic lift area. All of the samples will be contained in laboratory-supplied sample jars, labeled, and stored in a cooler on ice for submittal to Pace Analytical Services, Inc (Pace) using chain-of-custody controls. Samples will be analyzed in accordance with the IDEM RCG analytical requirements for gasoline, diesel, and used oil USTs. The samples for soil VOC analysis will be collected using Terra Core samplers in accordance with U.S. EPA Method 5035. If a water sample is collected from the UST pit, analysis for lead scavengers would be performed using U.S. EPA Method 8011.

Excavation of Petroleum Impacted Soil

Patriot will oversee the additional excavation of up to 2,000 tons of petroleum-impacted soil from the former loading rack and tank dike areas (where previous impacts were identified) and, if necessary, from the UST area. The soils that exhibit the highest adsorbed/dissolved concentrations of petroleum hydrocarbons will be excavated and transported to an approved off-site disposal facility.

A *Patriot* geologist, engineer or scientist will monitor the soil during excavation for evidence of contamination, including staining, odors, and VOC measurements on the PID. Contaminated soil will be loaded directly into dump trucks for transportation to the selected disposal facility. Excavation and disposal of contaminated soil will continue vertically and horizontally until field screening indicates that all contaminated soil has been excavated or until 2,000 tons of soil has been removed from the Site.

Excavation Confirmatory Soil Sampling

Additional confirmatory soil samples will be collected, as necessary, at the conclusion of the over-excavation activities. Samples will be collected in accordance with the IDEM RCG, the IDEM RPG, and the UST Closure Assessment Guidelines, as well as the project-specific Quality Assurance Project Plan (QAPP), using the methodology described above.

Application of ORC

Following completion of the soil excavation and confirmatory sampling, approximately 1,500 pounds of ORC will be applied to the base of the excavation area and mixed into the upper portion of the water-bearing zone. ORC is a proprietary formulation of food-grade calcium oxyhydroxide manufactured by Regenesis that increases the dissolved oxygen content in the subsurface, enhancing aerobic biodegradation of petroleum hydrocarbon compounds.

4.4 HEALTH AND SAFETY PLAN

A Site-specific Health and Safety Plan (HASP) was prepared for the remediation and monitoring activities. The plan includes elements contained in 29 CFR 1910.120. The HASP can be found as Attachment 6. The HASP was and will be reviewed with all field personnel prior to beginning each day's activities. Visitors to the Site during monitoring activities will also be required to review and comply with the HASP.

5.0 MONITORING/CONFIRMATION SAMPLING PLAN

This section describes the long-term monitoring plan for the Site, including soil sampling, groundwater monitoring, sample collection methods, and post remedial action confirmation sampling.

5.1 SOIL CONFIRMATION SAMPLING

The purpose of soil confirmation sampling (if necessary) is typically used to verify the effectiveness of the remediation strategy and attainment of the proposed cleanup objectives. At this Site, soil confirmation sampling will be performed following UST system removal and focused soil excavation. Sampling will be performed in accordance with the project-specific QAPP.

5.2 GROUNDWATER MONITORING

The purpose of groundwater monitoring is to verify the effectiveness of the remediation strategy and evaluate the progress of attaining the proposed cleanup objectives.

Groundwater Monitoring Well Installation

Following the completion of the UST closure and subsurface investigation, a monitoring well network consisting of five 2-inch diameter groundwater monitoring wells (MW-1 through MW-5) will be installed at the Site. The groundwater monitoring wells will be installed utilizing a Geoprobe® with hollow-stem augers or a hollow stem auger (HAS) drill rig. The wells will be screened in the appropriate saturated zone and constructed of Schedule 40 flush-threaded PVC with 10-foot 0.010-inch factory slotted screens. The screens will be positioned to account for season fluctuations within the groundwater level. The annular space around the well screens will be surrounded by washed quartz sand then capped with a minimum of 2-feet of hydrated bentonite. The remaining annular space will be filled with grout to the ground surface. The well tops will be completed with a locking manhole and flush-mounted protective cover set in a concrete pad.

Groundwater Monitoring Well Survey and Development

The groundwater monitoring wells will be surveyed relative to an arbitrary datum, set to 100 feet, with an accuracy of 0.01 foot vertical. The surveying rod will be placed on a marked point on the northern edge of the casing of each well to obtain the well's top of casing (TOC) measurement. In addition, GPS readings will be taken to obtain the latitude and longitude of each well.

The groundwater monitoring wells will be developed to provide adequate hydraulic communication between the wells and the surrounding water-bearing formation, and to ensure that the well yields representative water samples. Well development will involve removing a minimum of five volumes of water from the monitoring well using a purge pump.

Quarterly Groundwater Sampling

Following well installation, a quarterly monitoring program will be initiated and will continue for eight consecutive quarters. Sampling will be performed in accordance with the project-specific QAPP. Prior to sampling the monitoring wells, the depth to groundwater will be measured from a marked position on the north side of each well casing with an electronic water level meter to the nearest 0.01-foot. The water level meter will be properly decontaminated with an Alconox/distilled water rinse to prevent cross contamination. The groundwater levels will be used to determine groundwater flow.

The monitoring wells will be sampled using low-flow purging/sampling techniques in general accordance with the micro-purge sampling method outlined in the IDEM Micro-Purge Sampling Option Technical Guidance Document (TGD) (June 3, 1998, revised November 3, 2009) and applicable Patriot SOP(s).

A submersible pump will be used to purge and sample the monitoring wells at low flow rates of less than or equal to 400-500 milliliters per minute (ml/min). During low-flow purging, a multi parameter water quality probe with a flow through cell will be used to measure temperature, conductivity, turbidity, DO, pH, and ORP. Parameters will be measured every three (3) to five (5) minutes and will be recorded on field logs. Groundwater samples will be collected once the parameter values stabilize in accordance with the criteria stated in the IDEM Micro-Purge TGD. The pump will be decontaminated after use at each well and new disposable polyethylene tubing will be used at each well location. Note that the first groundwater sampling event will not occur until a minimum of 48 hours after the development of the groundwater wells.

The groundwater samples collected each quarter will be analyzed for:

- VOCs by U.S. EPA Method 8260;
- PAHs by U.S. EPA Method 8270SIM;
- Total lead by U.S. EPA Method 6010, and,
- Lead scavengers by U.S. EPA Method 8011.

One duplicate and one trip blank sample will be submitted for laboratory analysis for QA/QC.

Quarterly Groundwater Sampling Reports

A report will be prepared following the completion of each quarterly sampling event and receipt of the laboratory analytical data. The report will include a narrative of the activities performed, presentation of the field and laboratory data, and an interpretation of the results. A scaled Site Plan showing the sampling locations, potentiometric map, analytical data, and a copy of the laboratory analytical report will also be included in the report.

6.0 COMPLETION OF REMEDIAL ACTIVITIES

Upon the completion of the final groundwater monitoring event, a statistical data analysis of the contaminant concentrations in the groundwater at the Site will be completed using the Pro-UCL software. The statistical analysis will be submitted along with supporting documentation to request No Further Action (NFA) status under the IDEM RCG. An Environmental Restrictive Covenant (ERC) may be required as part of the NFA request to prevent future exposure to residual impacts. If contaminant concentrations or the statistical analysis do not support closure, then further monitoring and/or remediation may be required.

Well Abandonment

Upon receipt of NFA status at the Site, the groundwater monitoring wells will be abandoned by a licensed Indiana Water Well Driller in accordance with 312 Indiana Administrative Code (IAC) 13-10-2. The licensed Water Well Driller will complete the Well Abandonment Reports for submittal to the Program and the Indiana Department of Natural Resources.

7.0 SCHEDULE

Initiation of the remedial strategy proposed in this RWP will be implemented within 45 days of approval of the RWP and other required documents by the IDEM. UST closure/soil excavation activities can be completed within two weeks, and monitoring will continue for a minimum of two years (eight consecutive quarters) following completion of the UST closure/soil excavation activities.

8.0 REFERENCES

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